Influence of the body on exposimeter reading

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INTRODUCTION

Nowadays, exposimeters are extensively used in epidemiological studies to assess the exposure of a human to the electromagnetic fields used for radio frequency communication. Typically, an exposimeter is worn on the body (belt, back, chest, …). But, when worn on the body, an exposimeter measures the total fields (incident + scattered) instead of the incident fields, which are generally referred to as the exposure. This work investigated numerically the difference in exposimeter reading when worn on the body (measuring total fields) and placed off the body (measuring incident fields).

MATERIALS AND METHODS

This study investigated numerically the variation of the field levels between on-body and off-body exposimeter positions under identical exposure conditions. Therefore, we have employed our statistical multipath exposure tool [1] that has been extended for realistic human body models. This tool calculates very fast the fields in any exposure position around the human body for any (multipath) exposure sample. This tool is based on a limited set of single incident plane-wave simulations (FDTD or MoM/FEM) and linearity of Maxwell's equations. In this work, this method is used to evaluate the fields in a total of 415 locations around the human body arranged in three sets depending on the location: waist (16 positions), chest-to-ankle (304), and torso (95). Single incident plane wave exposure as well as multipath exposure in an urban-macro cell environment has been considered for the GSM downlink frequency of 950 MHz. The 6-year-old virtual family boy (VFB) has been selected as the human body model. The tissues have been assigned the dielectric properties as available in the Gabriel database [2].

RESULTS

Figure 1 shows the cumulative distribution function (cdf) of the rms electric field (E_{rms}) in a single exposimeter position at 5 cm in front of the VFB (belt height) and at the same location but without the VFB for 5000 exposure samples in an urban-macro cell environment at the GSM downlink frequency of 950 MHz. It is observed that field measured on the body underestimates the field measured in free-space. In order to quantify this deviation, the mean (μ) and the standard deviation (σ) of E_{rms} are determined for 5000 exposure samples in a total of 415 locations on the body. The total incident power (P_{inc}) for every exposure sample was 1 W/m^2. Three groups of locations are investigated: waist, chest-to-ankle and torso. The deviation (Δ) for $\mu(E_{rms})$ and $\sigma(E_{rms})$ between E_{rms} with body (total fields) and without body (incident fields) are defined as follows:

$$\Delta_{\mu} = \mu\left(E_{\text{rms,on-body,point}}\right)_{\text{dB}} - \mu\left(E_{\text{rms,free-space,point}}\right)_{\text{dB}} \quad (1)$$

$$\Delta_{\sigma} = \sigma\left[E_{\text{rms,on-body,point}}\right]_{\text{dB}} - \sigma\left[E_{\text{rms,free-space,point}}\right]_{\text{dB}} \tag{2}$$

Table 1 lists for each group of positions the minimum and the maximum Δ_{μ} and Δ_{σ}. Δ_{μ} and Δ_{σ} ranges from -3.9 dB to -1.8 dB and -2.2 dB to 3.3 dB, respectively, indicating the underestimation. These deviations do not differ significantly for different parts of the body.

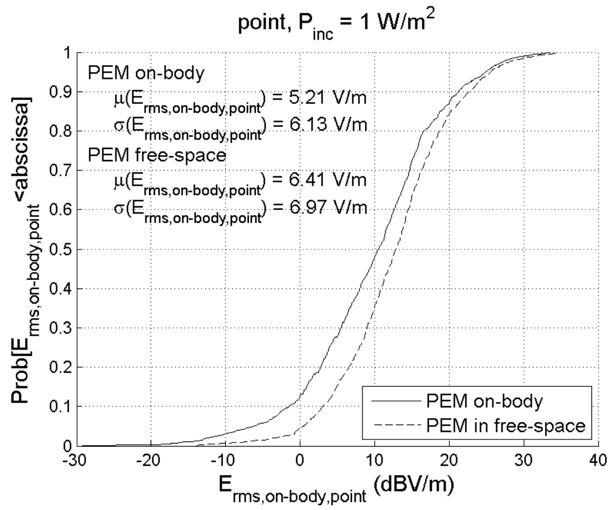

Figure 1: Cdf of Erms in a point at 5 cm in front of the VFB (belt height) and in the same point without VFB for 5000 exposure samples in an urban macro cell environment for the GSM downlink frequency of 950 MHz.

Table 1: Maximum and minimum deviation between μ and σ in a point with body and without body for three different areas of the body.

Area	Δ_{μ} (dB)	Δ_{σ} (dB)
Waist (16 positions)	-2.9 to -1.8	1.1 to 2.5
Chest-to-ankle (304 positions)	-3.9 to -1.3	-2.2 to 3.3
Torso (95 positions)	-3.5 to -1.4	0.4 to 3.4

CONCLUSIONS

This study showed that an exposimeter worn on the body of the virtual family boy underestimates the exposure (incident fields) by -3.9 dB to -1.4 dB for electromagnetic fields at the GSM downlink frequency of 950 MHz. These deviations do not differ significantly with the location on the body.

REFERENCES

[1] G. Vermeeren, W. Joseph, C. Olivier, and L. Martens. Statistical multipath exposure of a human in a realistic electromagnetic environment. Health Physics. 94:345-354, 2008.

[2] C. Gabriel. Compilation of the dielectric properties of body tissues at RF and microwave frequencies. Brooks Air Force Base, report no. al/OE-TR-1996-0037, 1996.